A Systematic Study of Episodic Localized Infiltration into Superheated Fractured Rock

Jens Birkholzer* and Clifford K. Ho**

* Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab),
1 Cyclotron Road, MS 90-1116, Berkeley CA 94720
(510) 486-7134; jtbirkholzer@lbl.gov
**Sandia National Laboratories (Sandia Lab),
P.O. Box 5800, Albuquerque, New Mexico 87185
(505) 844-2384; ckho@sandia.gov

Abstract

An important factor for the performance of the potential nuclear waste repository at Yucca Mountain, Nevada, is the amount of water seeping into the emplacement drifts. During the first thousand years after emplacement, a superheated rock region is predicted to form around the tunnels as a result of heat generation from the nuclear waste. In this rock region, vigorous vaporization will form a barrier that can significantly reduce the possibility of water contacting the waste packages. The performance of this barrier depends on the nature of flow in the unsaturated fractured rock. Episodic infiltration events flowing in localized preferential flow paths may penetrate far into the superheated rock to eventually reach the emplacement drifts. This differs from results obtained with spatially and temporally averaged infiltration conditions where potential penetration distances are typically underestimated.

In this paper, the probability of episodic infiltration reaching waste packages during the heating phase of the repository is studied in a systematic manner. The assumed infiltration events, while generally short in duration, are large in magnitude relative to the average infiltration. A semi-analytical solution is developed to determine the complex flow processes of such infiltration events when entering the hot rock environment. The solution scheme features a time-marching algorithm that tracks the propagation of finite masses of water flowing in vertical fractures, while an analytical solution is applied to consider mass losses resulting from vaporization caused by heat conduction from the adjacent rock. The long-term evolution of thermal-hydrological conditions in the rock is considered by simulating infiltration events at several discrete times after emplacement, covering the entire time period that repository temperatures are above boiling. Results indicate that episodic infiltration may indeed allow water to infiltrate considerable distances into the hot fractured rock. However, the heat generated from the waste packages is sufficient to reduce the probability of water entering waste emplacement drifts by a significant amount.

This work was supported by the Director, Office of Civilian Radioactive Waste Management, U.S. Department of Energy. Support was provided to Berkeley Lab through Contract No. DE-AC03-76SF00098 and to Sandia Lab through Contract No. DE-AC04-94AL85000.